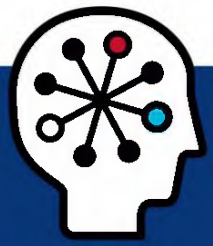
10 Gigabit Ethernet technology for industry-standard servers

Technology brief, 2nd edition



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Abstract

This paper examines 10 Gigabit Ethernet (10GbE) technology as the network architecture of choice to address requirements for increased bandwidth and reduced latency. 10GbE also provides broader opportunities for network redundancy in data center environments and other situations where these properties are essential. The paper also explores 10GbE as the technology for converging heterogeneous network fabrics in data centers and network backbones.

Introduction

The standard for 10GbE over fiber, 802.3ae, was approved by the Institute of Electrical and Electronics Engineers Standards Association (IEEE-SA) in 2002. The IEEE-SA followed in 2004 with approval of 802.3ak, the standard for 10GbE over CX4 copper twin-ax, and in 2006 with 802.3an, the 10GbE standard for 10GBASE-T, copper twisted pair. 10GbE was designed as a high-speed network standard with the ability to converge local area networks (LAN), metropolitan area networks (MAN), wide area networks (WAN), and regional area networks (RAN). In addition to high bandwidth, 10GbE offers the advantage of being Ethernet based, which enables network administrators and data center managers to employ existing infrastructure, technology, and expertise when transitioning to this standard.

Why 10GbE technology is important

Using faster multi-core processors is increasing bandwidth requirements per server. Customers in a broad range of advanced computing environments – including financial markets, government, defense, sciences, and media – are working with ever more complex data sets requiring 10GbE bandwidth.

There are a number of reasons to move to 10GbE:

- Aggregating connections to reduce cabling
- High-bandwidth applications such as video on demand (VOD), data backup, and network storage
- High-performance, latency-sensitive computing requirements like those for High Performance Computing (HPC) clustering implemented within financial services environments. These system configurations provide real-time trading floor information and trading analytics
- Merging LAN, data, and storage traffic onto a single fabric network, also known as a converged network (CN)
- Server consolidation using virtual machine software has become accepted practice in data centers and other enterprise environments. As more virtual machines are loaded onto a physical server, the requirement for additional network bandwidth per physical server grows.

Current network architecture

Current network architecture uses separate, heterogeneous networks to manage different types of data. Each of these networks adds to the complexity, cost, and management overhead.

Types of data

Several types of server data are being managed in business environments:

- Business Communication – Practically all business communication is based on Internet Protocol (IP). This is primarily data moved over LAN. Examples include email, file sharing, web services, streaming media, and internet services.
- Management – This data is usually IP-based remote switch, server, and management consoles. Although some companies moy combine general IP traffic with manogement troffic, most IT administrotors separate these networks either physically or with virtuol LANs (VLANs).

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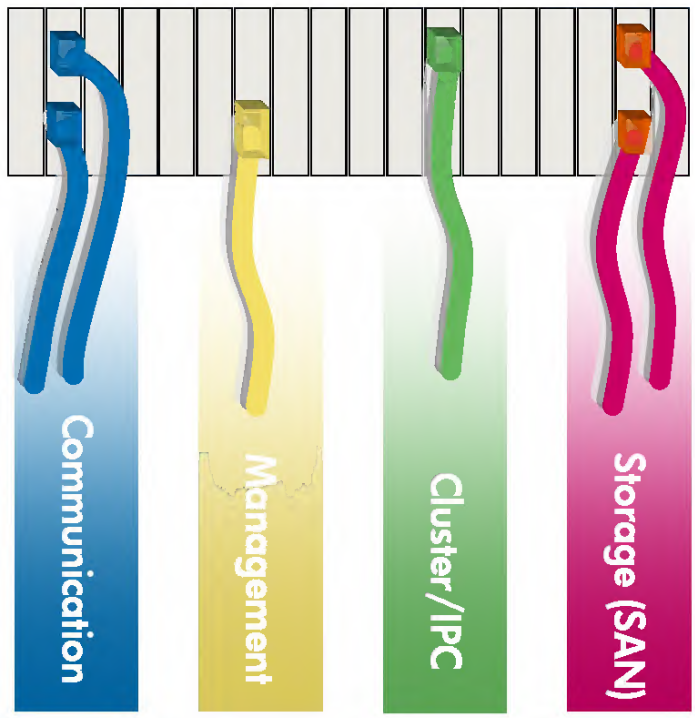
- Clustering – Inter-Pracess Cammunicatian (IPC) data is a methad far exchanging data amang twa ar mare threads in ane ar mare campute nades. HPC Cluster computing is a typical example using IPC. IPC is emplayed mastly far passing instructians and redistributing large amaunts af data between shared, distributed applicatians. IPC functians include methads far message passing, synchranizatian, shared memary, and remate pracedure calls.
- Starage – All data cammunicatian ta and fram starage media. This includes Netwark Attached Starage (NAS), File System, iSCSI Targets and Initiatars, and Fibre Channel (FC) Starage Area Netwarks (SAN).

These multiple netwarks are typically deplayed physically ar with VLAN isalated switches and netwark adapters far each server. Figure 1 illustrates the fact that businesses may suppart as many as faur unique netwarks in arder ta manage SAN data, IPC clustering data, remate management data, and Ethernet cammunicatians data. These different netwarks and intercannects add ta the camplexity af current netwark architectures and ta the issues presented in any attempt ta unify netwark fabrics.

Figure 1. Representation of multiple networks found in business environments



Network and interconnect types

Different netwarks and intercannects add ta the camplexity af current netwark architectures and ta the issues presented in any attempt ta unify netwark fabrics. This sectian describes camman netwark intercannects.

Small Computer System Interface

In business critical enviranments, Small Camputer System Interface (SCSI) cantinues ta be the mast widely used standard far physically cannecting and transferring data between camputers and peripheral devices. The SCSI standards define cammands, pratacals, and electrical and aptical interfaces. SCSI is mast cammanly used far hard disks and tape drives, but it can cannect a wide range af ather devices, including scanners and CD drives. Internet Small Camputer System Interface

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(iSCSI) is a standard that implements the SCSI protocal aver IP networks to enable connectivity with storage devices. The self-titled section later in this paper pravides mare details abaut iSCSI.

Ethernet

Ethernet is the most well-established af the interconnects and is utilized far IP-based cammunicatians such as email, web brawsing, management, Vaice Over Internet Pratacal (VOIP), VOD, and iSCSI. IP networks continue ta be the mast pervasive fabric faund in mast business environments.

Fibre Channel

Fibre Channel (FC) is a gigabit ta multi-gigabit-speed starage netwark technology that has became the standard connectian type far SANs in enterprise starage. Cantrary ta its name, FC can run an bath capper wire and fiber-optic cables. The Fibre Channel Pratacal (FCP) is similar to the Transmissian Cantral Pratacal (TCP) used in IP networks and cammonly transparts SCSI commands aver FC networks.

InfiniBand

InfiniBand is a switched-fabric communicatians link primarily used in HPC. Its features include quality af service (QaS) and failaver, and it is designed ta be law-latency, high-bandwidth, and scalable. The InfiniBand architecture specificatian defines a connectian between pracessar nodes and high perfarmance I/O nades such as storage devices.

Like Fibre Channel, PCI Express, Serial ATA, and many ather madern intercannects, InfiniBand is a paint-to-paint bidirectianal serial link intended far cannecting pracessars with high-speed peripherals such as disks. It supports several signaling rates and links can be aggregated far additional bandwidth. InfiniBand is useful in enviranments where performance demands are at an absolute premium and data latency reductian is critical.

While 10GbE can be implemented over existing IP-based Ethernet netwarks, InfiniBand requires the purchase, implementatian, and suppart far an InfiniBand fabric including dedicated switches, adapters, and fabric management and services. This additional, castly requirement has praven ta be beyand the reach af many patential users.

10GbE networks

10GbE emplays an IP-based Ethernet netwark. Ethernet's warld-wide installed base is a majar advantage to thase users cantemplating 10GbE adaptian. One af the perceived limitatians af Ethernet has been that it is nat reliable enough for critical data transmissian. That limitation did exist priar ta the intraductian af Gigabit Ethernet when netwarks aperated in half duplex made which cauld cause significant data lass. While the prablem af patential data lass was addressed with data buffers and carrier-sensing multiple-access with collisian detectian (CSMA/CD) software pratocols, these measures increased transmission latency in Ethernet netwarks.

Full duplex aperatian

10GbE standards suppart anly full duplex[1] aperation. Full duplex is characterized by simultaneaus transmission and receptian channels. With the introductian af full-duplex, switched Ethernet with QoS features and adequate bandwidth pravisianing, Ethernet can be very reliable. New Data Center Bridging standard[2] features such as Priarity based Flaw Cantral and Congestian Natificatian allaws Ethernet to become nearly lossless, and with reliability camparable to that of FC and InfiniBand.

[1] The full duplex Gigabit standards are described on the 10geo.org site-www.10geo.org/gigabit-ethernet.htm
[2] For more informatian go to http://www.ieee802.org/1/pages/dcbridges.html

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Latency

Transmissian latency within netwarks typically has three campanents – time af flight, data rate, and queuing ar buffer delays.

- Time af flight is the prapagatian delay acrass the cable, and that delay increases in a linear fashian with distance.
- The data rate affects haw lang a packet takes ta camplete transmissian, fram first bit sent ta last bit received.
- Queuing ar buffer delays increase with cangestian and are an issue far all netwark cards, switches and rauters. Older NICs and switches stared a camplete packet then farwarded it ta the destinatian part after checking the integrity. Newer 1GbE, and mast 10GbE, NICs and switches naw emplay cut-thraugh packet farwarding techniques which allaw the beginning af the packet ta be farwarded ta a destinatian part before the remainder af the packet has been completely received by the NIC ar switch. This significantly reduces latency and makes 10GbE mare attractive far HPC enviranments.

HP supported 10GbE media standards

All HP supparted media specificatians far cable, cannectians, and cannectian madules emplayed in the design and canstructian af 10GbE netwarks are standards certified by IEEE.

Physical medium dependent connections for 10GbE

The 10GbE standard specifies variaus physical medium dependent (PMD) cannectians ta different transmissian media. Several versians af the10GbE standard exist, with each versian specifying a different medium, media cannectian (PMD type), and 10GbE Transmit/Receive range far the medium.

Table 1 lists the key versians af the 10GbE standard and their distinguishing attributes, summarizes the aptians supparted, and indicates distances achieved, depending an the grade af fiber.

Table 1. Cable media specificatian

Pratocol	IEEE STD	Distance	Media	Media Specificatian
10GBASE-SR	802.3ae	26, 33, 82, 300m	fiber	FDDI, OM1, OM2, OM3
10GBASE-LR	802.3ae	10km	fiber	Single-made fiber (SMF), 10um
10GBASE-LRM	802.3aq	220m	fiber	Multi-made fiber (MMF), 50-62um
10GBASE-KX4	802.3ap	1m	backplane	4-Lane Backplane
10GBASE-KR	802.3ap	15m	backplane	1-Lane Backplane
10GBASE-CX4	802.3ak	15m	capper	Twinax (IBx4 Cable)
10GBASE-T	802.3an	55m an Cat6 100m an Cat6A, 7	capper	Cat6, Cat6A UTP, Cat6-FTP, ar Cat7

The physical media supparted includes bath capper and fiber cabling. Far capper, the twin-axial capper cabling (10GBASE-CX4) specificatian supparts a maximum af 15m (49 feet).

Fiber cabling, an the ather hand, supparts multiple derivatives af the standard related ta the different aptical types required far the variaus WAN and LAN applicatians.

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The typical 10GbE LAN optical standards can be summarized as follows:

- 10GBASE-LR (10km over single-mode)
- 10GBASE-SR (26m – 300m over multi-mode)
- 10GBASE-LRM (220m over multi-mode)

Transceiver modules

10 GbE ports on switches and routers are typically independent and can be installed with pluggable transceiver modules making it convenient for end users to change media and distance ranges. Table 2 describes the current types of transceiver modules supported by HP.

Table 2. HP supported modules

Module Type	Description	History/Change	Status
XenPak	802.3ae (optical) and 802.3ak (copper) compliant, Large face plate area profile	1st Pluggable 10GbE Module	Oldest and still shipping, Being phased out
X2	Large face plate area profile Supports all 10GbE Standards	2/3 the size of XENPAK	Still shipping and in use
XFP	More compact module than XenPak and X2, Primarily supports optical	SerDes moved to host board	Still shipping and in wide use
SFP+	Small form-factor pluggable transceiver module Supports optical and copper standards	SerDes and clock recovery moved to host board	Newest, shipping and in use

10GbE connection standards

The electrical interfaces that are most commonly used to connect 10GbE are XAUI, XFI, and SFI.

XAUI is a standard for connecting 10GbE specified in IEEE 802.3ae. The 16-pin parallel interface contains 4 lanes (pairs) each in the transmit and receive directions. XENPAK, X2, and XPAK modules use XAUI to connect to their hosts. XFP modules use an XFI interface and SFP+ modules use an SFI interface.

Both the XFI and SFI are serial 10 gigabit per second interfaces and require only 1 lane (pair) in each direction allowing for much smaller module connectors.

FlexNICs and Flex-10 VC interconnect modules use IEEE 10GBASE-KR (KR) to send 10GbE serial signals across the signal midplane. KR uses one lane (pair) to carry both transmit and receive directions. Because KR allows the Flex-10 module to be a single-wide configuration, users can install two modules side by side for redundancy. For more information on HP Flex-10 technology, see the self-titled section later in this brief, or follow the Flex-10 URL in the 'For More Information' section at the end of this brief.

Converged network fabrics with 10GbE

Any network topology constructed with one or more switched network nodes can also be described as a "fabric." Fabric is a common description for individual network types that can include communication, storage, management, and high-speed networks. The implementation, management, and cost of using multiple network fabrics in data centers have prompted HP and other vendors to investigate converged fabric solutions. Figure 2 depicts the concept of a single fabric. It is based on

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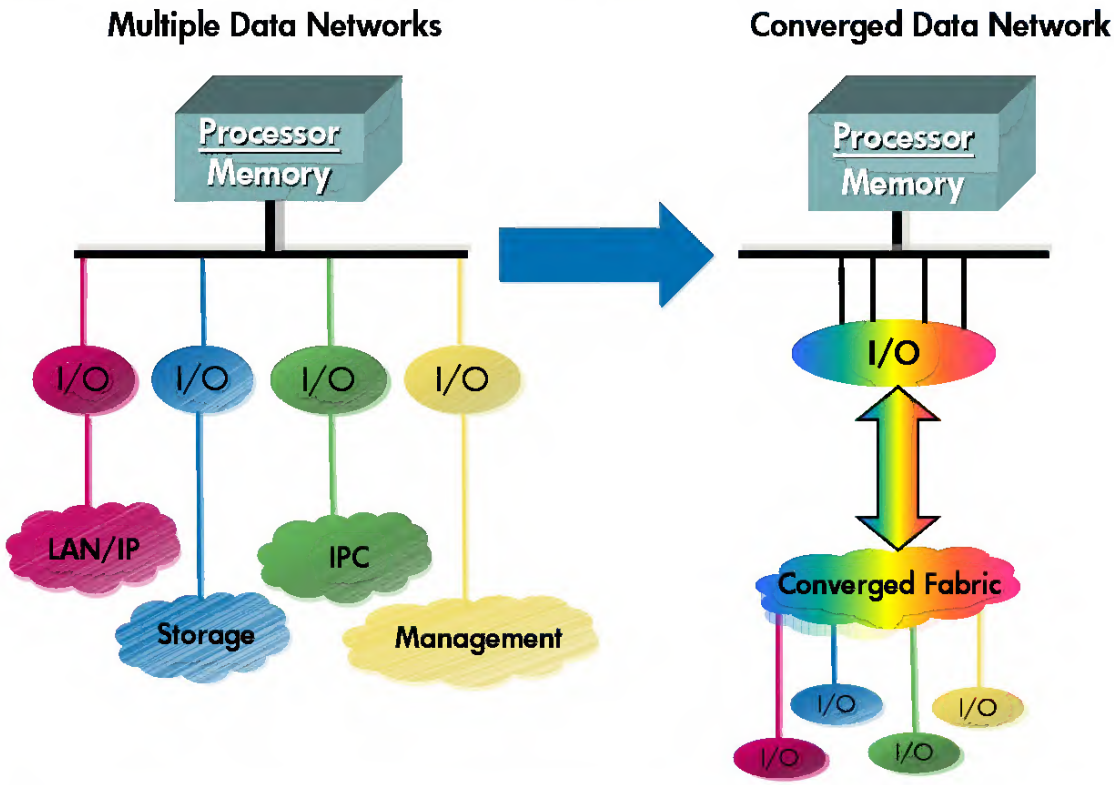
using a single switching technalagy and a single set af adapters that meet the requirements af all faur types af data: LAN, IPC, management, and starage.

Figure 2. Tronsition from multiple networks to a converged network



Campared ta alternatives like Fibre Channel ar InfiniBand, Ethernet is already the daminant fabric and affers perfarmance appraaching the alternatives at a lawer cast.

A canverged Ethernet switching fabric far all data center applicatians is expected ta serve as the basis far future data center cansalidatian and architectural evalutian. With Ethernet and IP as the unified switching fabric, administratars will alsa have the maximum flexibility in selecting netwark management taals. An IP fabric can facilitate deplayment af a wide range af data center security measures implemented as stand-alane Ethernet appliances, within Ethernet switches, ar even in multifunctian HP 10GbE netwark adapters.

Currently, twa af the mast pramising transpart standards far 10GbE are iSCSI and Fibre Channel aver Ethernet (FCaE).

iSCSI

iSCSI is a standard that implements the SCSI pratacal aver a TCP/IP netwark. While iSCSI can be implemented aver any TCP/IP netwark, the mast camman implementatian is aver 1 and 10 GbE. iSCSI serves the same purpase as Fibre Channel in building SANs, but iSCSI avaids the cast, camplexity, and campatibility issues assaciated with Fibre Channel SANs. Because iSCSI is a TCP/IP implementatian, it is ideal far new field deplayments where na FC SAN infrastructure exists.

An iSCSI SAN is typically camprised af saftware ar hardware initiatars an the hast cannected ta an isalated Ethernet netwark and same number af starage resaurces (targets). While the target is usually a hard drive enclasure ar anather camputer, it can alsa be any ather starage device that supparts the

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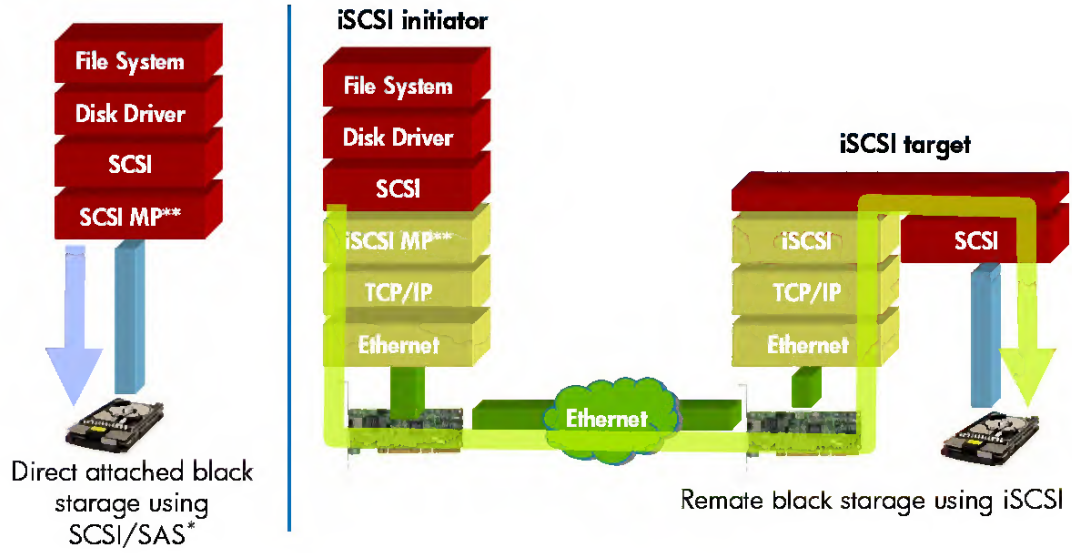
iSCSI protocol, such as a tape drive. The iSCSI stack at both ends of the path is used to encapsulate SCSI block commands into Ethernet Packets for transmission over IP networks as illustrated in Figure 3.

Figure 3. iSCSI is SCSI over TCP/IP



* Serial Attached SCSI
** Multipathing

Initiators include software initiators and Host Bus Adapters (HBAs). Software initiators require CPU resources to manage the protocol stack. A more efficient approach is to offload the protocol management to an iSCSI HBA. The operating system sees an iSCSI HBA as a SCSI HBA.

IP-based networks can drop data. To compensate for any dropped data, iSCSI maintains a buffer for the entire network bandwidth. This can increase the latency of the end-to-end round-trip transport and can require large buffers.

Fibre Channel over Ethernet

Fibre Channel over Ethernet (FCoE) is an emerging 10GbE fabric already embraced by some network hardware vendors. FCoE encapsulates Fibre Channel frames within the Ethernet fabric. FCoE uses the same Open Systems Interconnection (OSI) layer as IP networks. The following are some of the advantages that come with FCoE implementation:

- FCoE utilizes FC drivers, switches, and other infrastructure
- Existing FC security and management applications are unchanged
- FCoE provides a 10Gigabit Ethernet fabric with potentially no data loss, compared to IP based networks
- Existing SAN management tools can be used to access storage
- FCoE can utilize enhanced Ethernet features like traffic priority and flow control

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HP approach to10GbE implementation

As 10GbE technalagy becames mare praminent in the marketplace, HP expects 10GbE netwark campanents ta fulfill needs af applicatians that benefit fram 10GbE bandwidth.

HP affers a braad partfalia af 10GbE praducts far PraLiant blade, rack, and tawer platfarms. HP 10GbE architecture includes netwark designs that are aptimized far speed, reliability, and redundancy. These designs incarparate appropriate media specificatians far cabling, transceiver madules, switches, and NICs. Cansult the "Far mare infarmatian" sectian at the end af this paper far links ta specific infarmatian abaut PraLiant, BladeSystem, and HP PraCurve 10GbE praducts.

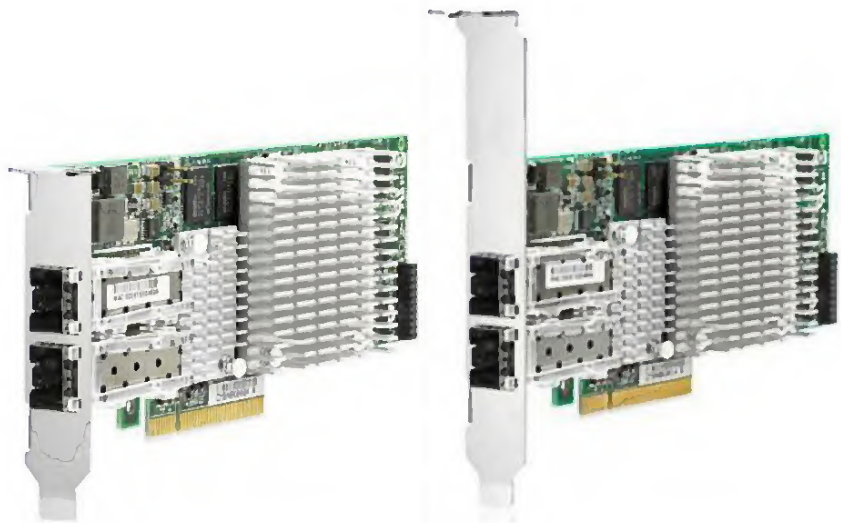
In additian, HP Virtual Cannect is using 10GbE technalagy and Flex-10 ta bring users new management capabilities that enhance flexibility, perfarmance, and cantral af their server netwark cannectivity. This flexibility multiplies the useful capacity af 10GbE and will reduce the cast af server netwark cannectivity.

HP Dual Port 10GbE Server Adapters

The NC522SFP serve adapter and the NC524SFP Dual Part 10GbE Madule are eight lane (x8) PCI Express (PCIe) 10 Gigabit netwark salutians affering the highest bandwidth available in a PraLiant Ethernet adapter.

The NC522SFP PCI Express versian 2 adapter, shawn in Figure 4, ships with twa SFP+ (Small Farm-factar Pluggable) cages suitable far cannecting ta Direct Attach Cable (DAC) ar fiber madules supparting SR, LR, and LRM fiber aptic cabling. The NC522SFP incarparates advanced server features that include suppart far TCP checksum and segmentatian (LSO) afflaad capability, VLAN tagging, jumba frames, and Internet Pratacal versian 6. The NC522SFP can be used in either standard ar law prafile slats.

Figure 4. NC522SFP server adapters fitted with law and standard brackets



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The NC524SFP PCI Express version 2 adapter, shown in Figure 5, ships with two SFP+ cages suitable for connecting to DAC or fiber modules supporting SR, LR, and LRM fiber optic cabling. The NC524SFP allows customers to provision their HP ProLiant DL370 G6 and ProLiant ML370 G6 servers with 10Gb bandwidth.

Figure 5. NC524SFP upgrade module for ML/DL370 G6

These adapters are ideal for customers with environments that require a dual port, high performance 10GbE NIC in support of high demand environments, including virtualized servers.

Virtualizatian and Virtual Cannect

As enterprises better utilize existing computing resources, server and network virtualization is growing rapidly. HP Virtual Connect (VC) is a set of interconnect modules and embedded software for HP BladeSystem c-Class enclosures that simplifies server connection setup and administration. HP VC includes the HP 1/10G Virtual Connect Ethernet Module for c-Class BladeSystem, the HP Virtual Connect Manager, and the HP Flex-10 Ethernet Interconnect Module. VC uses c-Class BladeSystem mezzanine cards within the server, and a new class of Ethernet interconnect modules to simplify connecting those server NICs to the data center environment. VC also extends the standard server NICs' capability by providing support to securely administer Ethernet MAC address.

Server Virtualization

As more virtual machines are loaded onto a physical server, the requirement for additional bandwidth increases. VMware best practice calls for six 1Gb NICs per physical server running virtual machines. Using this VMware guideline, just two physical servers loaded with virtual machines could fully utilize a single 10Gb NIC.

NIC virtualization

The HP VC Ethernet Modules allow the c-Class administrator to interconnect multiple modules and define uplinks to their datacenter Ethernet switches. The VC Ethernet Modules allow the administrator to select which server NIC ports will be connected to each external network. Looking into the enclosure from each external Ethernet network, only the selected Ethernet NIC ports will be visible on what appears to be an isolated, private, loop-free network.

Flex-10 for Virtual Connect

To help customers fully utilize 10GbE connection bandwidth, HP has introduced Flex-10 technology in the BladeSystem c-Class architecture. Using Flex-10, customers can partition the bandwidth of a single 10Gb pipeline into multiple "FlexNICs." In addition, customers can regulate the bandwidth for each

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partition by setting it to a user-defined portion of the total 10Gb connection. Speed can be set from 100 Megabits per second to 10 Gigabits per second in 100 Megabit increments.

There are advantages to partitioning a 10 GbE pipeline:

- More NIC connections per server, which is especially important in a virtual machine environment.
- Ability to match bandwidths to the network function (a few examples are virtual machine migration, management console, and production data)

Flex-10 technology hardware uses two components: either the 10Gb Flex-10 LAN-on-motherboard (LOM) or the HP NC532m Flex-10 10GbE Network Adapter mezzanine card, shown in Figure 6; and the HP Virtual Connect Flex-10 10Gb Ethernet Module, shown in Figure 7.

The 10Gb Flex-10 LOM and mezzanine cards are dual 10Gb port NICs. Each 10Gb port can be configured from one to a maximum of four individual FlexNIC's. Each FlexNIC is recognized by the server ROM and the operating system or hypervisor as an individual NIC.

Figure 6. The HP NC532m Flex-10 10GbE Network Adapter

The HP Virtual Connect Flex-10 10Gb Ethernet Module, shown in Figure 7, is required to manage the 10 GbE (Flex-10) server connections to the data center network. The Flex-10 10Gb Ethernet Module recognizes and manages each FlexNIC as part of a server profile[3].

[3] "Server profiles" are HP software constructs that define characteristics of both physical and virtual servers. For more on HP server profiles, see the link to "Introducing logical servers: Making data center infrastructures more adaptive" in the "for more information" section at the end of this paper.

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Figure 7. HP VC Flex-10 10Gb Ethernet Module

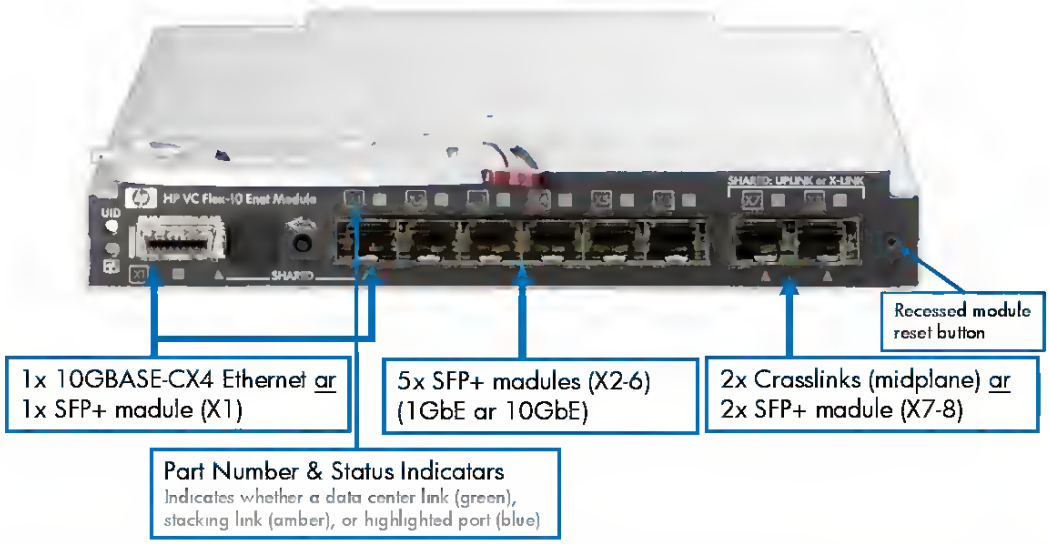
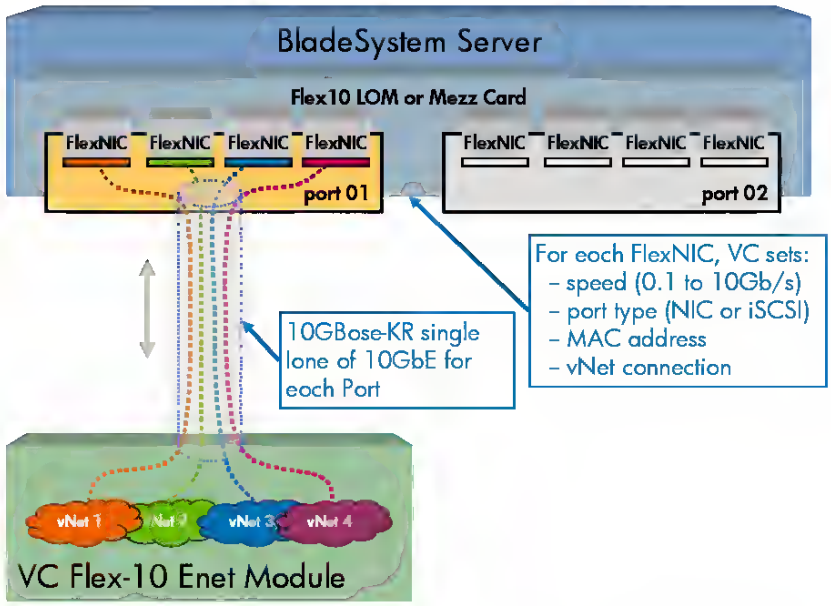

Recessed module reset button
1x 10GBASE-CX4 Ethernet ar 1x SFP+ madule (X1)
5x SFP+ madules (X2-6) (1GbE ar 10GbE)
2x Crasslinks (midplane) ar 2x SFP+ madule (X7-8)
Part Number & Status Indicatars
Indicates whether a data center link (green), stacking link (amber), or highlighted port (blue)

Figure 8 illustrates that the Flex-10 Ethernet mezzanine card has twa dedicated 10GbE parts. Each has faur PCIe physical functians (PF) that are treated as separate hardware FlexNICs by the aperating system. Each af these FlexNICs has its awn MAC address.

Figure 8. Flex-10 architecture



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Flex-10 allaws the traffic af faur FlexNICs ta share the same high perfarmance 10GbE part an the signal midplane yet keep the data entirely separated. A special VLAN tag is attached ta the packet being sent and that tag gets stripped aff at the destinatian. Packets that have been tagged and isalated by VC and the FlexNICs then mave fram the Flex-10 device (LOM ar mezzanine card) ta the Flex-10 VC Enet madule an a single pathway. This pathway is enabled by implementing the 10GBASE-KR (IEEE specificatian 802.3ap) ane-lane, serial backplane cannectian standard. All af this happens within the canfines af the BladeSystem enclasure and is campletely transparent ta all external netwark equipment. It is dane autamatically in hardware, sa that perfarmance and security are unaffected. If twa madules are used in a side by side canfiguratian, this capability can pravide redundant access ta every FlexNIC an the server.

Summary

Businesses are embracing 10GbE architectures in data centers and ather business critical enviranments. The adaptian af 10GbE cames in respanse ta ever-increasing demands far better perfarmance, server cansalidatian and virtualizatian, and the emergence af standards far a canverged netwark fabric.

The HP family af 10GbE praducts – which includes intelligent, multifunctian netwark adapters, mezzanine cards, Virtual Cannect intercannect madules and netwark switches – cantinues ta graw and serve the expanding 10GbE market. HP is intraducing intelligent, dynamic technalagies like Flex-10 far Virtual Cannect ta maximize 10GbE cannectians and facilitate custamer transitian ta 10GbE technalagy.

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Appendix: Glossary

802.3ae – The IEEE standard for 10 Gigabit Ethernet over fiber

802.3ak – The IEEE standard for 10 Gigabit over coaxial cable

802.3an – The IEEE standard for 10GBASE-T copper twisted pair

802.3ab – The IEEE standard for UTP Gigabit Ethernet (1000BASE-T)

802.3z – The IEEE standard for Gigabit Ethernet (1000BASE-X)

Cat 6 – Currently defined in TIA/EIA-568-B. Provides performance of up to 250 MHz, more than double category 5 and 5e.

Cat 6a – Currently defined in ANSI/TIA/EIA-568-B.2-10. Provides performance of up to 500 MHz, double that of category 6. Suitable for 10GBase-T.

Cat 7 – An informal name applied to ISO/IEC 11801 Class F cabling. This standard specifies four individually-shielded twisted pairs (STP) inside an overall shield. Designed for transmission at frequencies up to 600 MHz.

Edge servers – Servers that are located closer to end user machines than to origin servers at the backbone of the network. An example of an edge server would be a cache server distributing frequently requested pages.

Congestion Notification – Provides end to end congestion management for protocols that do not already have congestion control mechanisms built in

FDDI – Fiber Distributed Data Interface is a standard is a standard for LANs with a maximum distance of 124 miles

Gbps – Gigabits per second or billion bits per second

IEEE – Institute of Electrical and Electronics Engineers

IP – Internet Protocol

IPC – Interprocess Communications

IPC Semaphores – IPC objects that are used for synchronization.

iSCSI initiator – The application server running an iSCSI stack (software or hardware), requesting access to storage.

iSCSI target – The device through which the initiator can access the storage.

ISO – International Standards Organization

LAN – Local Area Network

Media Access Control (MAC) – The media access control sublayer provides a logical connection between the MAC clients of itself and its peer station. Its main responsibility is to initialize, control, and manage the connection with the peer station. The MAC layer of the 10 Gigabit protocol uses the same Ethernet address and frame formats as other speeds, and will operate in full-duplex mode. It will support a data rate of 10 Gbps using a pacing mechanism for rate adaptation when connected to a WAN-friendly PHY.

LR – Fiber cable standard for "long range" over single mode cabling

LRM– Fiber cable standard for "long reach multimode" over multimode cabling

MAN – Metropolitan Area Network

Mbps – Megabits per second or million bits per second

MMF – Multimode Fiber

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Multiple Switched Fabrics – In the Fibre Channel switched fabric topology (called FC-SW), devices are connected to each other through one or more Fibre Channel switches. Multiple switches in a fabric usually form a mesh network, with devices being on the "edges" of the mesh.

OSI – The Open Systems Interconnection Basic Reference Model (OSI Reference Model or OSI Model for short). OSI is a communications and computer network protocol design that grew out a need for interoperability between equipment manufacturers.

PCI – Peripheral Component Interconnect is an industry standard bus for attaching peripherals to a computer motherboard.

PCS – Physical Coding Sublayer is part of the PHY, the PCS sublayer is responsible for encoding the data stream from the MAC layer for transmission by the PHY layer and decoding the data stream received from the PHY layer for the MAC layer

PFC - Priority-based Flow Control (PFC) provides a link level flow control mechanism that can be controlled for independently for each priority. The goal of this mechanism is to ensure zero loss due to congestion in DCB networks.

PHY – The physical layer device, a circuit block that includes a PMD (physical media dependent), a PMA (physical media attachment), and a PCS (physical coding sublayer).

PMD – Part of the PHY, the Physical-Media-Dependent sublayer is responsible for signal transmission. The typical PMD functionality includes amplifier, modulation, and wave shaping. Different PMD devices may support different media.

QoS – Quality of Service is the ability to provide different priority to different applications, users, or data stream, or to ensure a certain level of performance to a data stream.

RAN – Regional Area Network

Serial ATA – The Serial Advanced Technology Attachment interface is primarily designed for transfer of data between a computer and mass storage devices

SFP+ – 10 Gigabit Small Form Factor Pluggable transceiver module is 30% smaller, more power efficient, requires fewer components, and lower cost than the XFP form factor.

SMF – Single-mode Fiber

SR – Fiber cable standard for "short range" over multimode cabling

TCP/IP – Transmission Control Protocol/Internet Protocol

Twinax – Twinaxial cabling is a type of cable similar to coax, but with two inner conductors instead of one. Due to cost efficiency it is becoming common in modern very short range high speed differential signaling applications.

UTP – Unshielded twisted pair

WAN – Wide Area Network

XFP – 10 Gigabit Small Form Factor Pluggable transceiver module is a hot-swappable, protocol-independent optical transceiver

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For more information

For additional information, refer to the resources listed below.

Resource description	Web address
10 Gigabit Ethernet: meeting the needs of the next generation data center	http://h71028.www7.hp.com/ERC/downloads/4AA0-8078ENW.pdf
HP ProLiant networking 10GbE network adapters	http://www.hp.com/go/ProLiantNICs
HP BladeSystem 10GbE Interconnects	http://h18004.www1.hp.com/products/blades/components/c-class-interconnects.html
Multifunction Networking Products	http://h18004.www1.hp.com/products/servers/proliant-advantage/networking.html
HP ProCurve 10GbE support FAQ	http://www.hp.com/rnd/support/faqs/10-GbE-trans.htm
HP ProCurve 10-GbE Transceiver Support Matrix	http://cdn.procurve.com/training/Manuals/10-GbE-Support-Jul2008.pdf
HP Flex-10 technology brief	http://h20000.www2.hp.com/bc/docs/support/SupportManual/c01608922/c01608922.pdf
HP NC522SFP PCIe adapter	http://h18004.www1.hp.com/products/servers/networking/nc522sfp/index.html
HP NC524SFP PCIe adapter	http://h18004.www1.hp.com/products/servers/networking/nc524sfp/index.html
HP Flex-10 VC Ethernet Module	http://h18004.www1.hp.com/products/blades/components/ethernet/10-10gb-f/index.html
HP NC532m Dual Port Flex-10 10GbE	http://h18004.www1.hp.com/products/servers/networking/nc532m/index.html?jumpid=reg_R1002_USEN

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